made without departing from this invention in its broader aspects and, therefore, the appended claims are to encompass within their scope all such changes and modifications as fall within the true spirit and scope of this invention.

I claim:

1. An apparatus for generating at least two control signals, said apparatus comprising:

a support;

an arm member disposed within said support, said arm member being moveable in an arcuate path within said support;

a contact member slidably mounted on said arm member, said contact member being slidable along said arm member;

a first sensor coupled to said arm member for sensing movement of said arm member along said arcuate path; and

a second sensor coupled to said contact member for sensing linear movement of said contact member along said arm member.

2. The apparatus of claim 1 further comprising:

first guide means disposed along said arm member; and

second guide means disposed on said contact member, said second guide means matingly coupled with said first guide means so as to facilitate the movement of said contact member along said arm member.

3. The apparatus of claim 2 wherein said first guide means comprise first and second grooves horizontally disposed in first and second side walls, respectively, of said arm member, said second guide means comprising first and second flanges disposed on first and second side walls of said contact member, respectively.

4. The apparatus of claim 1 wherein said arm member is pivotally coupled to said support at a pivot point, said arm member moving in said arcuate path as said arm member pivots about said pivot point.

5. The apparatus of claim 1 further comprising:

a track means disposed within said support, said track means defining said arcuate path; and

one or more guide elements disposed on an outer surface of said arm member, said one or more guide elements being matingly coupled to said track means for facilitating the movement of said arm member in said arcuate path.

6. The apparatus of claim 1 wherein said first sensor detects the magnitude and direction of arcuate movement of said arm member along said arcuate path and generates a first control signal in response thereto.

7. The apparatus of claim 1 wherein said second sensor detects the magnitude and direction of linear movement of said contact member and generates a second control signal in response thereto.

8. The apparatus of claim 1 further comprising a third sensor coupled to said arm member, said third sensor detecting a downward pressure on said contact member and in response thereto generating a signal for implementing a first predetermined function.

9. An apparatus for generating at least two control signals, said apparatus comprising:

a support;

an arm member having a first end portion pivotally coupled to said housing at a point, said arm member being rotatable about said point;

a contact member slidably mounted on said arm member, said contact member being slidable along said arm member;

a first sensor coupled to said arm member for sensing arcuate movement of said arm member; and

a second sensor coupled to said contact member for sensing linear movement of said contact member along said arm member.

10. The apparatus of claim 9 wherein said support is of a size such that said apparatus is capable of being operated with one hand of a person.

11. The apparatus of claim 9 wherein said first sensor generates a first control signal representing the angle and direction of rotation of said arm member, said first control signal being capable of being used to alter the position of a cursor or pointer in a first direction on a display screen.

12. The apparatus of claim 9 wherein said second sensor generates a second control signal representing the magnitude and direction of linear movement of said contact member, said second control signal being capable of being used to alter the position of a cursor or pointer in a second direction on a display screen.

13. The apparatus of claim 9 further comprising a third sensor disposed on said arm member, said third sensor detecting a downward pressure on said contact member.

14. The apparatus of claim 13 wherein said third sensor generates a third control signal indicative of said downward pressure on said contact member, said third control signal implementing a first predetermined function.

15. The apparatus of claim 9 further comprising a first actuator, wherein in response to a first feedback signal said first actuator restrains said rotation of said arm member.

16. The apparatus of claim 15 wherein said first actuator is contained within said first sensor.

17. The apparatus, of claim 15 further comprising a second actuator, wherein in response to a second feedback

signal said second actuator restrains the linear movement of said arm member.

18. The apparatus of claim 17 wherein said second actuator is contained within said second sensor.

19. The apparatus of claim 9 wherein said contact member has a concave upper surface so that a human thumb may matingly situate on said contact member.

20. The apparatus of claim 9 wherein said arm member has disposed therein one or more first guide means, said contact member having disposed thereon one or more second guide means, each of said first guide means being matingly coupled with an associated one of said second guide means for facilitating sliding of said contact member along said arm member.

21. The apparatus of claim 20 wherein said first guide means comprise first and second grooves horizontally disposed in first and second side walls, respectively, of said arm member, said second guide means comprising first and second flanges disposed on first and second side walls of said contact member, respectively.

22. The apparatus of claim 9 wherein said housing has a bottom surface, said apparatus further comprising:

one or more cavities formed in said bottom surface of said housing;

one or more switches, each of said switches being associated with and coupled to an associated one of said cavities.

23. The apparatus of claim 22 wherein said switches comprise pressure sensitive devices, the actuation of which generates one or more fourth control signals for implementing one or more second predetermined functions.

* * * * *

SUBA17

24. A handheld force feedback device coupled to a computer for providing positioning signals to said computer for positioning a cursor displayed on a display device, said device comprising:

a support housing able to be held by a hand of a user;

a user manipulatable member engageable and moveable by a thumb of said user in two dimensions relative to said support housing while said support housing is held by said hand of said user, wherein said movement in said two dimensions positions said cursor in two screen dimensions on said display device;

at least one sensor coupled to said user manipulatable member and sensing movement of said user manipulatable member in said two dimensions, said sensor providing positioning signals which control said positioning of said cursor on said display device;

at least one actuator coupled to said user manipulatable member, wherein said actuator provides a force in at least one of said dimensions of said user manipulatable member, wherein said force facilitates the selection of options or icons displayed on said display device based on feedback signals generated by an application running on said computer; and

a trigger sensor for detecting a trigger command from said user, said trigger command including moving said user manipulatable member approximately orthogonally to said two dimensions.

25. A force feedback device as recited in claim 24 wherein said two dimensions are provided substantially in a single plane.

SUBA27

26. A force feedback device as recited in claim 25 wherein said motion of said user manipulatable member is orthogonal to a plane defined by said planar dimensions.

27. A force feedback device as recited in claim 24 wherein said at least one actuator is a first actuator, and further comprising a second actuator coupled to said user manipulatable member, wherein said second actuator provides a force in the other of said dimensions of said user manipulatable member.

28. A force feedback device as recited in claim 24 wherein said user manipulatable member is coupled to an arm member having rotary motion about a pivot point to provide motion in one of said two dimensions, wherein said actuator is coupled to said arm member to output forces about said pivot point.

29. A force feedback device as recited in claim 28 wherein said rotary motion of said arm member is limited to an arcuate path of less than ninety degrees.

30. A force feedback control device as recited in claim 28 further comprising a second actuator, and wherein said first actuator is grounded to said housing and wherein said second actuator is carried by said arm member.

31. A force feedback device as recited in claim 28 wherein said user manipulatable member is a sliding contact member which can be moved in a linear dimension approximately perpendicular to an axis of rotation of said arm member and in substantially the same plane as said rotary motion, thereby providing said motion in one of said two dimensions.

SUB A37

32. A force feedback device as recited in claim 24 wherein said cursor can be positioned and displayed icons or options can be selected by a single hand of said user.

33. A force feedback device as recited in claim 24 wherein said at least one actuator is one of a motor, a brake, and a solenoid.

34. A force feedback device as recited in claim 24 wherein said user manipulatable member is coupled to a centering spring return that causes a bias on said user manipulatable member to return to a center position after it has been moved from said center position.

35. A force feedback device as recited in claim 24 wherein a centering spring bias on said user manipulatable member may be electrically actuated by a signal received from said computer, allowing said force feedback device to have a centering mode and a non-centering mode, selected by said computer.

36. A force feedback device as recited in claim 24 wherein said cursor can be used to select an icon, wherein said trigger command selects said icon when said cursor is positioned over said icon.

37. A force feedback device as recited in claim 36 wherein said at least one actuator outputs a force to augment or restrain motion of said cursor on said screen.

SUB A47

38. A force feedback device as recited in claim 24 wherein said image is a video game character.

39. A force feedback device as recited in claim 24 further comprising a trigger actuator for causing resistance to said motion of said trigger command by said user based on a feedback signal from said computer.

40. A force feedback device as recited in claim 24 further comprising at least one additional control provided on said housing and operable by said user, wherein said additional control is operated by a different hand of said user than said hand operating said user manipulatable member.

SUB A57

41. A method as recited in claim 24 wherein said at least one actuator outputs detents when said cursor overlaps or is positioned near an icon displayed on said screen.

42. A method as recited in claim 41 wherein detents provide tactile click stops correlated with targets or options displayed on said screen.

43. A method as recited in claim 42 wherein a detent correlated with a target or option is deactivated once said target or option is selected by said user using said force feedback device.

44. A method as recited in claim 41 wherein said user selects said target or option by causing a trigger signal to be sent to said computer, said trigger signal caused by a pressing motion of said user manipulatable member.

45. A method as recited in claim 41 wherein said detents are output for use in a word processor or spreadsheet program provided on said computer.

46. A force feedback device coupled to a computer for providing positioning signals to said computer for manipulating an image displayed on a screen by said computer, said device comprising:

a support housing;

a user manipulatable member coupled to said housing and engageable and moveable by one or more digits of said user in two degrees of freedom relative to said housing, wherein at least one of said degrees of freedom is a rotary degree of freedom about an axis of rotation;

SUB A57

at least one sensor coupled to said user manipulatable member and sensing movement of said user manipulatable member in said two degrees of freedom, said sensor providing positioning signals which control positioning of said image on said screen by said computer;

at least one computer controlled brake coupled to said user manipulatable member, wherein said brake provides a drag in at least one of said degrees of freedom of said user manipulatable member; and

a trigger sensor for detecting a trigger command from said user, said trigger command including a pressing motion by said digit causing said user manipulatable member to move in a trigger degree of freedom different from said two degrees of freedom.

47. A force feedback device as recited in claim 46 wherein said housing is able to be held and operated by a single hand of a user.

48. A force feedback device as recited in claim 46 wherein the other of said two degrees of freedom is a linear degree of freedom and wherein said rotary degree of freedom allows a pivoting motion of said digit of said user.

49. A force feedback device as recited in claim 47 wherein said two degrees of freedom are approximately in the same plane.

SUB A67

50. A force feedback device as recited in claim 46 wherein said at least one brake is a first brake providing a drag in a first of said two degrees of freedom, and further comprising a second computer controlled brake coupled to said user manipulatable member, wherein said second brake provides a drag in a second one of said degrees of freedom of said user manipulatable member.

51. A force feedback device as recited in claim 50 wherein said user manipulatable member is coupled to an arm member having rotary motion about a pivot point, wherein said first brake is coupled to said arm member to output forces about said pivot point.

52. A force feedback device as recited in claim 51 wherein said user manipulatable member is a sliding member which can be moved along at least a portion of said arm member in a linear degree of freedom, and wherein said second brake outputs forces in said linear degree of freedom.

SUB A7

53. A force feedback device as recited in claim 46 wherein said cursor can be used to select an icon displayed on said screen, wherein said trigger command selects said icon when said cursor is positioned over said icon.

54. A force feedback device as recited in claim 46 wherein said brake outputs a force controlled by said computer to provide tactile clicks correlated with targets or options displayed on said screen.

55. A force feedback device as recited in claim 46 wherein said device is provided in an automobile dashboard or automobile steering wheel.

SUB A8

56. A force feedback device as recited in claim 46 wherein said at least one brake includes an electromagnetic coil.

57. A force feedback device as recited in claim 46 wherein said at least one brake employs an electro-rheological compound.

58. A method for providing positioning signals to a computer from a user for manipulating a displayed cursor on a screen and for providing force feedback to said user, said method comprising:

providing a handheld force feedback device coupled to said computer, said handheld force feedback device including a thumb member engageable and moveable by a thumb of said user in two degrees of freedom while said device is held by said hand of said user;

sensing movement of said thumb member in said two degrees of freedom using at least one motion sensor and providing positioning signals to said computer in accordance with said sensed movement, wherein said positioning signals are used by said host computer to move a cursor displayed on a screen in two dimensions of said screen; and

providing a drag in said two degrees of freedom of said thumb member using at least one braking actuator coupled to said thumb member, wherein said drag facilitates selection of an icon or option displayed on said screen by said cursor.

59. A method as recited in claim 58 further comprising detecting a trigger command from said user, said trigger command including a pressing motion of said

SUBA97 thumb member, wherein said trigger command is sent to said computer to be used to select an option or icon displayed on said screen with said cursor.

60. A method as recited in claim 58 wherein said two degrees of freedom are substantially in a single plane.

61. A method as recited in claim 58 wherein one of said degrees of freedom is a rotary degree of freedom and another of said degrees of freedom is a linear degree of freedom.

SUBA97 62. A method as recited in claim 58 wherein said brakes output drag to hinder motion of a rotating member coupled to said thumb member and hinder a sliding motion of said thumb member.

63. A handheld force feedback device coupled to a computer for providing positioning signals to said computer for positioning a cursor displayed on a screen, said device comprising:

a support housing;

a user manipulatable member coupled to said housing and engageable and moveable by a digit of said user in two degrees of freedom relative to said housing while said housing is held by said hand of said user, wherein at least one of said degrees of freedom is a rotary degree of freedom about an axis of rotation;

a spring return mechanism coupled to said user manipulatable member to provide a centering bias on said user manipulatable member toward a center position of said rotary degree of freedom when said user manipulatable member has been moved from said center position;

at least one sensor coupled to said user manipulatable member and sensing movement of said user manipulatable member in said two degrees of freedom, said sensor providing positioning signals which control said positioning of said cursor on said screen;

at least one actuator coupled to said user manipulatable member, wherein said actuator provides a force in one of said degrees of freedom of said user manipulatable member; and

a trigger sensor for detecting a trigger command from said user, said trigger command including a pressing motion causing said user manipulatable member to move in a trigger degree of freedom different from said two degrees of freedom.

SUB A10 7

64. A force feedback device as recited in claim 63 wherein said spring return mechanism is electrically actuated by an external signal received from said computer, allowing said spring return mechanism to be selectively applied in a centering mode and allowing said spring return mechanism to have no effect in a non-centering mode.

65. A force feedback device as recited in claim 64 wherein said external signal is controlled by a video game running on said computer.

66. A force feedback device as recited in claim 64 wherein said spring return mechanism is coupled to a pivotable arm member providing said rotary degree of freedom, and further comprising a centering spring coupled to said user manipulatable member to provide a centering bias in another of said two degrees of freedom.

67. A force feedback control provided in an automobile and coupled to an on-board vehicle computer system for providing input to said computer system, said control comprising:

a user manipulatable member provided in an automobile dashboard, said member engageable and moveable by a digit of said user in two degrees of freedom relative to said dashboard, wherein at least one of said degrees of freedom is a rotary degree of freedom about an axis of rotation;

at least one sensor coupled to said user manipulatable member and sensing movement of said user manipulatable member in said two degrees of freedom, said input to said computer system based on positioning signals provided by said sensor;

at least one actuator coupled to said user manipulatable member, wherein said actuator provides a force in one of said degrees of freedom of said user manipulatable member; and

a trigger sensor for detecting a trigger command from said user, said trigger command including a pressing motion causing said user manipulatable member to move in a trigger degree of freedom different from said two degrees of freedom.

68. A force feedback control as recited in claim 67 wherein said user manipulatable member is manipulated by said user to provide communication with said on-board computer system.

69. A force feedback control as recited in claim 67 wherein said input to said computer system controls a vehicular navigation system.

70. A force feedback control as recited in claim 67 wherein said two degrees of freedom of said user manipulatable member define a plane.

71. A force feedback control as recited in claim 67 wherein said trigger degree of freedom is orthogonal to said plane.

72. A force feedback control as recited in claim 67 wherein said actuator is a motor.

73. A force feedback control as recited in claim 67 wherein said actuator is a passive brake.

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